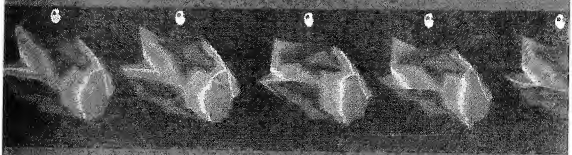
APPENDIX 1

Cardiac Mapping



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The Interpretation of Cardiac Electrograms

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Introduction

As early as 1915, Lewis and Rothschild, who studied the cardiac activation sequence in the dog by recording potentials directly from the heart, wrote: "It must be evident that it is a matter of first concern of us, to ensure a correct interpretation of our curves."[1]

The term *electrogram*, as opposed to the term *electrocardiogram* (ECG), denotes a recording of cardiac potentials from electrodes directly in contact with the heart, a definition introduced by Samojloff in 1910.[2-4] Electrograms form the raw data for cardiac mapping, which has been defined as "a method by which potentials recorded directly from the surface of the heart are spatially depicted as a function of time in an integrated manner,"[5] and which is important as both a research tool and a method for guiding therapy.

The most common method of cardiac mapping is isochronal or activation mapping. A cardiac isochronal map outlines the locations of the various recording sites in relation to anatomical landmarks of the heart and represents the local activation of myocardium at each recording site by a single figure, the time of activation.[6,7] In an isochronal map, only a single activation time can be represented at each site and all other information also contained in the electrograms is discarded.[6] In isochronal mapping, the interpretation of the excitation sequence of the heart rests entirely on the individual activation times assigned to each electrogram, which is why the correct interpretation of individual electrograms is of crucial importance. Alternative mapping methods, namely isopotential and isoderivative mapping,[7] place emphasis on interpreting a sequence of maps, rather than a set of individual electrograms,[7] the correct interpretation of which is often difficult and at times uncertain.

The objective of this chapter is to review the interpretation of individual cardiac electrograms in 2 parts: (1) in respect to timing local activation, and (2) in respect to information contained in the morphologies of electrograms. Throughout this

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Methodology of Cardiac Mapping

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Cardiac mapping involves making some measurement of the heart in 3-dimensional space and then displaying that measurement on a similar 3-dimensional representation. That measurement could be of its mechanical function, electrical function, structure, or some combination of these. To add further complexity, the measurement itself could be a value (such as activation time) or an array (such as conduction velocity, with a magnitude and direction). In the current literature, cardiac mapping usually refers to measuring the electrical activity of the heart in 2 or 3 dimensions and displaying that activity on 2-dimensional representations. The electrical activity is often activation times or isopotentials that are measured directly from electrodes in contact with the tissue or are calculated from body surface electrodes or other electrodes that are not in contact with the tissue. This chapter provides a brief introduction into the techniques of this category of cardiac mapping, and then illustrates how we have dealt with some typical complications to this type of mapping in infarct regions and during atrial fibrillation.

Overview of Current Techniques

Most electrical mapping of the heart is done with either unipolar or bipolar electrodes and with either simultaneous multielectrode arrays or sequential recordings from several electrodes on the distal end of a catheter. A unipolar (or single-ended) measurement is usually made relative to some distant, stable reference on the body, the exact position of which is generally not considered critical to the data acquisition. A bipolar (or differential) measurement is between 2 electrodes that are often closely (≤1 cm) spaced. Often, the activation time of the cells beneath the electrode must be determined. Criteria used to derive activation times from the recorded signals are discussed in detail elsewhere in this book. Briefly, the maximum negative derivative is the most widely used criterion for defining activation time in a unipolar electrogram. The most widely used criterion for bipolar electrograms is the peak of the main deflection.[1]

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